Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of:	)	
	)	
Digital Audio Broadcasting Systems	)	MM Docket No. 99-325
And Their Impact on the Terrestrial	)	
Radio Broadcast Service	)	

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Comments of Barry D. McLarnon, P. Eng.

I. INTRODUCTION

I am filing the following comments as an individual. I am a independent consultant and Professional Engineer, registered in the Province of Ontario. I have more than thirty years of experience in the analysis and design of communications systems, both analog and digital. My experience with digital broadcasting systems, primarily the Eureka 147 DAB system, dates back to the late 1980s.

II. NRSC-5 CHARTS A PATH WHICH HAS NOT BEEN PROPERLY STUDIED

With regard to NRSC-5, I would like to draw your attention to the fact that there are elements contained in this standard for which little or no test data has been filed on this docket. The Commission should be very careful not to authorize modes of operation utilizing these elements in the absence of information that clearly shows their impact. The most obvious elements in this category are the all-digital modes of operation. By approving NRSC-5, the Commission would be setting into motion an inexorable transitional path towards the use of these modes, despite the fact that they have not been

studied and evaluated in any depth. It would be irresponsible, and extremely poor spectrum management, to embark on a path with such far-reaching consequences without first conducting thorough systems studies.

It should be apparent to everyone by now that the most glaring flaw in the hybrid IBOC systems is that they are not “on channel”, and instead make use of first adjacent channels to transmit the digital signal. There seems to be a widespread notion that this is a temporary problem that will disappear in a future transition to all-digital operation, but an examination of NRSC-5 reveals that this would not be the case. Both all-digital systems will, by design, continue to transmit significant power outside their nominal channel limits. A transition to all-digital operation in the AM and FM broadcast bands is an opportunity to finally “get it right”, but this opportunity will be lost if this path to the digital future is prematurely set in concrete.

For the AM band, digital transmission holds the promise of expanded and more reliable coverage areas, especially at night. The key to this improvement is the major reduction in co-channel protection needed by a digital system compared to AM, and the virtual elimination of adjacent channel interference as a factor in determining coverage. This goal can be realized if the digital transmissions are confined to the 10 kHz bandwidth of an AM channel; however, the all-digital AM IBOC system specified in NRSC-5 has a bandwidth occupancy of 20 kHz. The consequence of this choice would be that the potential gains in nighttime coverage due to digital operation would be largely negated by co-channel interference emanating from first adjacent skywave signals. There is no technical reason why the digital signal cannot be restricted to the authorized channel. As a comparison, consider the DRM system, a worldwide open standard that

has modes utilizing only 10 kHz bandwidth that offer bit rates as high as 35 kb/s. This would clearly be a better choice for the AM band than the system specified in NRSC-5. I note that several major AM ownership groups are now pushing for a reduction in AM bandwidth to 10 kHz. It seems very ironic that these same groups are willing to embrace a future digital system in which the bandwidth reverts to 20 kHz. It is time to take a step back and do a thorough study to determine which digital system is best for the AM band in ITU Region 2. Similar considerations apply to the FM band.

III. UNTESTED ELEMENTS IN THE HYBRID MODES SPECIFIED IN NRSC-5

A more immediate concern with NRSC-5 are the hybrid modes that would be used during the remainder of this decade, and probably for much longer than that. As I have pointed out in previous comments[1], compatibility of the hybrid IBOC systems with analog reception was characterized using a woefully inadequate sampling of receivers. Despite this shortcoming, the test results showed that certain receivers showed significant degradation in signal-to-noise ratio (SNR) when hybrid IBOC was added to the desired AM or FM station.

The AM IBOC system, as described in the NRSC-5 normative reference documents SY_IDD_1012s and SY_IDD_1082s, includes a Power Level control to set the relative power levels of the secondary and tertiary sidebands. The diagrams in SY_IDD_1012s depicting the hybrid spectrum (Figures 5-1 and 5-2) *show the effects of the low power setting only*. The high power setting increases the power of all digital subcarriers within 10 kHz of the carrier frequency by 6 dB, with the exception of the

[1] Comments of Barry D. McLarnon, dated June 14, 2004; Reply Comments of Barry D. McLarnon, dated July 15, 2004.

subcarriers below 2.5 kHz, where the increase is reduced on a sliding scale. It appears that all test results thus far released by iBiquity were obtained using the low power setting of this control. The high power setting has the potential to cause further SNR degradation in susceptible AM receivers, and thus should not be authorized in the absence of thorough test results in which this setting was used. In any future receiver tests, an adequate sampling of receivers should also be used.

The FM IBOC system, as described in the NRSC-5 normative reference documents SY_IDD_1011s and SY_IDD_1026s, includes three Extended Hybrid modes (MP2, MP3 and MP4) that specify the addition of digital subcarriers in the region between 101 and 129 kHz offset from the FM carrier frequency (i.e., closer to the analog signal than the standard hybrid mode subcarriers). No test results for any of these extended modes have been released by iBiquity. However, some limited test results for the MP3 mode have recently been submitted by NPR[2]. Several of the tested receivers showed significant decreases in SNR of up to 6 dB when the IBOC mode was changed from MP1 (standard hybrid) to MP3. Unfortunately, there are no results showing how much the SNR of these receivers are already degraded by going from FM alone to MP1 IBOC mode. These tests were quite limited in scope, but they do demonstrate a compatibility problem with a class of analog receivers that is quite sizable. Clearly, transmissions using the extended hybrid modes should not be authorized until further compatibility tests are conducted, and here again, the sample population of receivers tested should be much larger than has been the case to date.

[2] *Host Compatibility Measurements for the Extended Hybrid Mode of IBOC Digital Audio Broadcasting*, National Public Radio, October 29, 2004.

IV. THE TRUE NATURE OF HYBRID IBOC HAS BEEN MISREPRESENTED

In addition to the concerns voiced above, I continue to have serious misgivings about the impact on the AM and FM bands of operating the hybrid systems described in NRSC-5. As I have stated previously, the proponents and evaluators of these systems have not provided an accurate and unbiased assessment of their potential to interfere with existing analog services. Many commenters on this docket have explained the fallacy behind using an emission mask, intended to contain transient analog modulation products, to "hide" a continuous duty cycle digital signal having a much higher average power. Moreover, that signal occupies adjacent channels, thus completely negating the Commission's desire to endorse digital radio systems that are "on channel". I will summarize briefly my previous comments on bandwidth occupancy of the hybrid IBOC signals, none of which have been refuted by proponents of those systems.

The occupied bandwidth of a signal has a well-defined engineering meaning that is codified in 47CFR§2.202. Using the same mathematical model for the FM signal that has been used in the past for IBOC system analysis, it is easy to show that adding hybrid IBOC at the -20 dBc digital power level specified in NRSC-5 increases the occupied bandwidth by 100%. It is also possible to calculate the average power deposited into a first adjacent channel, before and after adding hybrid IBOC. This calculation shows that the addition of hybrid IBOC to an average FM signal increases the interference power in a first adjacent channel by 16 dB.

My measurements on several AM stations that follow the NRSC-1/NRSC-2 standards showed that the occupied bandwidths (again, as defined in 47CFR§2.202) are actually quite small, in the 1.0 to 1.25 kHz range. When hybrid IBOC as specified in

NRSC-5 is added to the AM signal, however, the occupied bandwidth increases dramatically, to about 28 kHz. Therefore, hybrid IBOC increases the occupied bandwidth of the AM signal by a factor of about 25, or 2400%. I also measured the average power deposited into the first adjacent channels by these stations, and then calculated how it would change with the addition of hybrid IBOC. For the three stations measured, adding hybrid IBOC would increase the interference power in a first adjacent channel by an amount ranging from 18 to 39 dB.

V. INTERNATIONAL AGREEMENTS AND PROTECTION

It should be abundantly clear that operation of the hybrid AM IBOC system as defined in NRSC-5 is not permissible under the terms of several international agreements dealing with AM broadcasting, including Rio 1981, USA-Canada 1991, and USA-Mexico 1987. See, for example, Section 4.2 ("Class of emission") of the Rio agreement. It would be presumptuous and arrogant for a country that is signatory to those agreements to authorize the use of such emissions without first obtaining the agreement of the other signatory countries to make appropriate amendments to the agreements.

Many commenters on this docket have pointed out that the adjacent channel usage of the hybrid IBOC system makes a mockery of existing protection rules, but there still seems to be a lack of appreciation of how grave this problem really is. It should be obvious that the digital components of hybrid signals should be treated as separate entities in interference analysis. One factor that is usually overlooked, however, is that interference to analog from a digital source cannot be equated directly to an analog interference source having the same power. This is particularly true for AM signals,

where the majority of the power is in the carrier and therefore does not contribute to audible co-channel interference, provided that the frequency offset between the carriers is small. Fortunately, we have a useful reference point for this situation in the DRM system. A DRM emission and an AM IBOC sideband having similar bandwidth are virtually indistinguishable, since they use the same type of modulation and would have equivalent effects on an AM detector. Studies by the ITU have determined that in order to provide the same level of protection to a co-channel analog station, a DRM station must operate at 6 to 7 dB lower average power than the carrier power of an AM station assigned to that channel. Turning this around, we can say that a conservative estimate of the interference caused by a co-channel primary AM IBOC sideband is equivalent to that caused by an AM station having 6 dB higher power. In other words, we must add at least 6 dB (ITU-R Recommendation BS.1615 specifies 7 dB) to the co-channel protection rules when the interfering signal is digital.

Consider second adjacent protection. Stations in the US are required to provide protection to second adjacent stations in Canada and Mexico such that the D/U (desired/undesired) ratio on their protected 0.5 mV/m contours (0.1 mV/m in the case of Class A stations during daytime), within the borders of those countries, is no lower than -29.5 dB. First adjacent protection is 0 dB D/U. However, a second adjacent hybrid IBOC station creates a first adjacent primary digital sideband that is only 16 dB down. If the station is just at the -29.5 dB second adjacent protection limit, then its first adjacent digital signal is at -13.5 dB D/U, or 13.5 dB in excess of the first adjacent protection level. The nature of the digital signal, as explained above, makes the interference even worse than if it came from an AM first adjacent signal at that excessive level. Even if the

primary digital sideband power is reduced by 6 dB, as suggested for interference mitigation in the Commission's interim rules for IBOC operation, this still falls well short of solving the problem. The preceding example highlights the potential for cross-border second adjacent interference from hybrid IBOC, but instances of domestic interference of this type will be far more numerous. A number of reports of such interference in daytime hybrid IBOC operation have already come to light, and this is just the tip of the iceberg, since only about 1.4% of the nation's AM stations are using hybrid IBOC so far.

The nighttime first adjacent interference problem is even worse, since it will affect more stations. There is no protection from first adjacent skywave signals, so stations are at the mercy of first adjacent stations that convert to hybrid IBOC. Class A stations, with their 0.5 mV/m nighttime protected contours, plus those Class B stations that have a reasonably low NIF contour, are the ones that will suffer the most damage. First adjacent skywave signals of the order of 0 dB D/U are common on these contours at night, though the D/U ratios may fall significantly lower than that. Most AM receivers have little difficulty delivering a listenable signal under these circumstances. However, if a first adjacent station at 0 dB D/U goes IBOC, it creates a co-channel interfering signal at 16 dB D/U. As explained above, we must also include an additional 6 dB factor to allow for the fact that the interfering signal is digital, so the interference is actually approximately equivalent to that of a co-channel AM station at 10 dB D/U. This is 16 dB more than would be permitted by the co-channel protection rules, and would completely destroy reception on the "protected" contour. Here again, a 6 dB reduction in primary digital sideband power would not solve this problem. There would still be a 10 dB shortfall in protection, and badly impaired reception near the protected contours of the

affected stations.

VI. CONCLUSION

In the light of these facts, it is simply amazing that AM IBOC deployment has been allowed to proceed this far. In other parts of the world, such poor engineering and spectrum management would be regarded as a joke. It is time to call a moratorium on this deployment, and begin a study to find a more reasonable means of transitioning to digital operation in the AM broadcast band.

The hybrid FM IBOC system also has some serious problems, but since it is the lesser of the two evils and has fewer international implications, I have chosen not to expound at length on them. I do sound a note of caution, however, with regard to authorizing operation with those modes described in NRSC-5 which are largely untested.

For both the AM and FM bands, adoption of the NRSC-5 standard would establish a *de facto* path towards adopting all-digital systems that have thus far seen very little scrutiny. The use of these systems would have far-reaching consequences that have been completely unexplored up to this point. Rather than lock into such a path, the Commission should instead be collaborating with other Region 2 countries to conduct comprehensive systems studies to determine the best usage for these broadcasting bands in the new era of digital transmission.

Respectfully submitted,

Barry D. McLarnon, P.Eng.
2696 Regina Street
Ottawa, ON K2B 6Y1
Canada